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We would like to thank the anonymous referee for providing comments and suggestions to improve our manuscript.

**Overall Comment:**

**The manuscript “Cloud Speed Sensor” by Fung et al., provides interesting and simple method to estimate the cloud motion, however, the weakest party is insufficient data validation analysis. I suggest add more data for different cloud speed because in this version of manuscript the cloud speed is in the narrow range of variation (3-6 m/s).**

**Response:** It is very rare to find a day with high cloud speeds in coastal San Diego where stratocumulus and fair weather cumulus are the most common cloud types and typical cloud heights are 500 to 1500 m. We are in the process of acquiring funding for further testing of the CSS in other climates and data resulting in a wider range of cloud speeds will be obtained.

**Specific Comments:**

**C1. Page 9041, line 17-19:** The meaning of this sentence does not fit this section, my suggestion it to remove it.

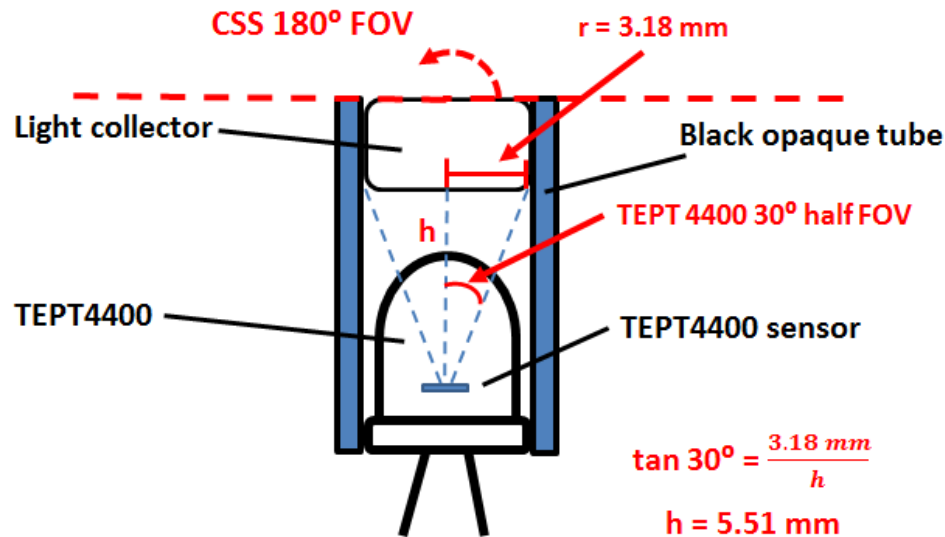
**Response:** The sentence has been removed as suggested.

**C2. Page 9021, line 3:** Why the FOV of the sensor is only 30deg? What in case when the sun zenith angle is larger than 15 deg? At San Diego latitude the minimum solar zenith angle is about 10 deg which means that this instrument can be used only during summer and close to noon time. Maybe it is not FOV but half field of view? Anyway the real FOV of sensor should be provided. What is a tilt error for each sensor? Is it in order of 1 deg or larger? Could you add same discussion of that issue on the uncertainty of wind speed and direction? The same for the cosine error of detector

**Response:** While it is true that the FOV for a bare TEPT4400 sensor is  $30^\circ$  on either side of its normal axis, the FOV of the CSS is the entire sky hemisphere. The translucent acrylic collector above each TEPT4400 sensor causes scattering of the incident direct beam such that solar positions that are nominally outside the FOV of the bare TEPT4400 sensor result in irradiance input to the TEPT4400 through scattering in the optical assembly. Therefore, the optical assembly gives the CSS a cosine response over the full  $-90^\circ$  to  $90^\circ$  tilt exposure to the sky and is thus responsive to the full sky hemisphere.

The spacing between the diffuser light emitting surface and the TEPT4400 sensor reduces the effect of TEPT4400 tilt errors. As shown in Fig A, full TEPT4400 sensor exposure to the overhead light field would be accomplished with a vertical separation of  $h = 5.51$  mm. In

the CSS design,  $h$  was decreased to 2.78 mm such that a tilt error of up to  $48.8^\circ$  would still allow the TEPT4400 FOV to be contained within the diffuser area.



**Fig A:** Side view of optical assembly containing the TEPT4400. In the ideal case depicted here the vertical spacing between the diffuser and the TEPT4400 sensor could be  $h = 5.51$  mm. To reduce the effect of tilt errors,  $h = 2.78$  mm was chosen instead.

Since this misunderstanding triggered most of the criticisms of the reviewer, we wanted to clarify this immediately in this response and will clarify the manuscript to differentiate the FOVs of the TEPT4400 sensor versus the CSS upon receipt of more reviewer comments.

**C3. Page 9042, line 6:** Why the criterion of the signal reduction by cloud passing the sun is only 7%? This means that CSS is sensitive to very thin clouds such high level cirrus and low level stratus fractious. In the last case I expect large error due to fact that shape of this cloud is very complicated and not well defined. In my opinion this threshold should at least 30% of the clear sky solar flux

**Response:** With the available SRAM memory on the microprocessor, the measurement time series is limited to 9 seconds and is only rarely long enough to capture a complete transition from clear to cloudy (or vice versa). Thus, only parts of the transition are observed and a smaller signal reduction criterion is required to maintain a sufficient amount of data for the third quality control step, which is the 30 min median filter.

An empirical study using data from the days indicated in Table 2 showed that a 7% (corresponding to about  $60 \text{ W m}^{-2}$ ) solar variability (SV) threshold of the full-scale Max32 reading (10 bit or 1024 counts) presented the right compromise between data retention rate and data quality. Consistent (i.e. identical median filtered) CMV results were found for

SV between 7-15% while twice the amount of data could be retained for SV = 7% versus SV = 15% (Table I).

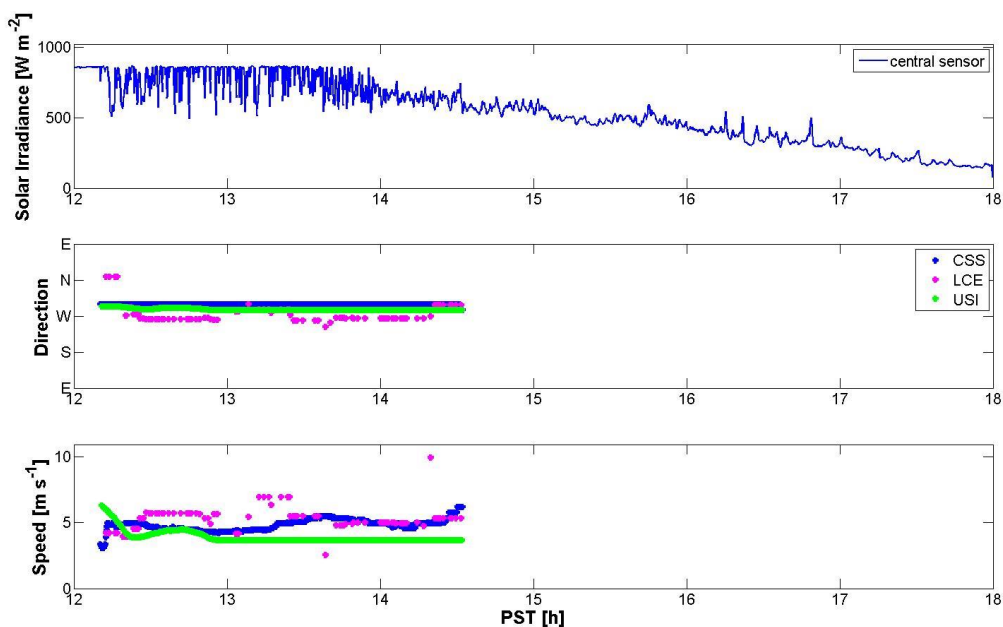
**Table I** Impact of solar variability threshold on data retention rate.

Date in 2013	Total raw CMV	Total CMV pass QC (minimum 7% of full-scale reading)	Total CMV pass QC (minimum 15% of full-scale reading)	Total CMV pass QC (minimum 20% of full-scale reading)
<b>23 Jul</b>	<b>1611</b>	<b>314</b> 19.5 %	<b>176</b> 10.9 %	<b>86</b> 5.3 %
<b>08 Aug</b>	<b>1876</b>	<b>424</b> 22.6 %	<b>236</b> 12.6 %	<b>151</b> 8.0 %

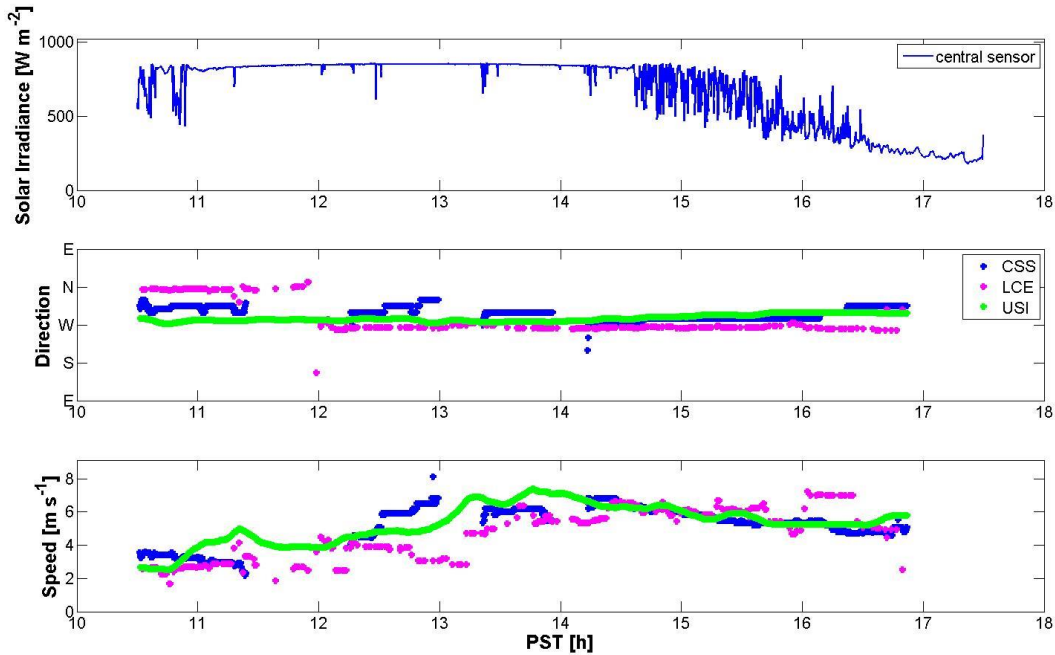
Increased QC CMV data availability will also improve the robustness of the median filter. Hence, we select 7% SV threshold to retain as much information as possible.

**C4. Page 9058, Fig5:** I propose to remove all data from top panel except for the central sensor because it is impossible to read some difference between sensors. In case of cloud direction and speed the lines should be replaced by the dots or different points. In current version the long blue (green) strait line is misleading. The same for fig. 6.

**Response:** Figures 5 and 6 were edited as suggested by the reviewer.



**Fig 5:** Solar irradiance and cloud motion vector for the cloud speed sensor deployment on 23 July compared to USI and LCE results. Luminance measurements were calibrated against a nearby Li-200 silicon pyranometer to obtain  $\text{W m}^{-2}$  of solar irradiance. The central sensor saturates at  $860 \text{ W m}^{-2}$ .

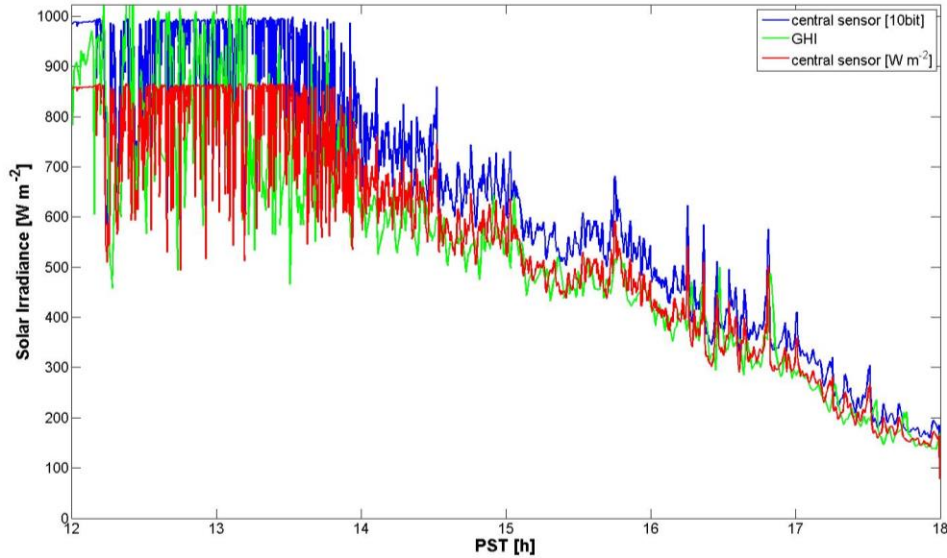


**Fig 6:** Solar irradiance and cloud motion vector detected during the CSS deployment on 8 August 2013.

**C5. Page 9058, capture to Fig.5:** It suppose noted that calibration of the central sensor of CSS versus pyranometer has some limitation due to different FOV. In case of pyranometer its 180 and CSS only 30 deg. Therefore such calibration overestimates the solar radiation in the CSS. Probably because of that the solar irradiance (top panel) during overcast condition since 14:00 PST is unrealistic high. If case of low level clouds the solar flux cannot by 800-700  $\text{W/m}^2$  for 100% cloud cover!!!.

**Response:** As mentioned in response to **C2**, the CSS is responsive to the full sky hemisphere. Therefore, the CSS and pyranometer have the same FOV ( $\sim 180^\circ$ ) and can detect solar radiation at zenith angles greater than  $15^\circ$  (i.e. also after 1400 PST).

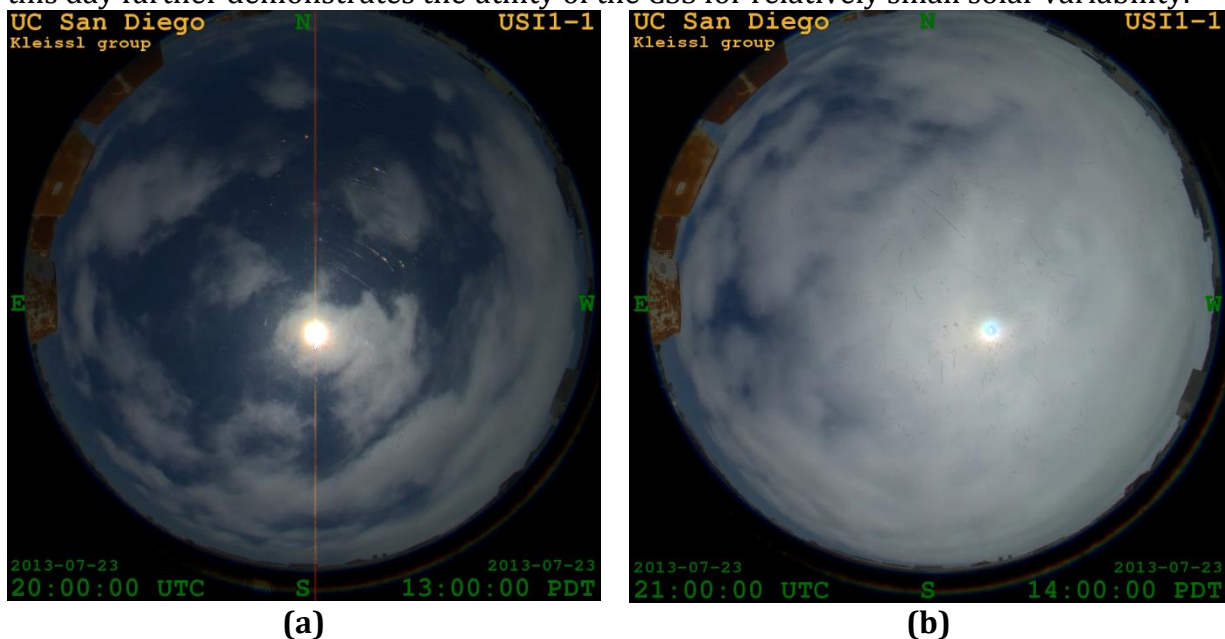
In addressing we realized that the original top panel was showing the raw Max32 counts reading rather than the calibrated solar irradiance ( $\text{W m}^{-2}$ ). This error has been corrected and Figs. 5 and 6 shown in the response to the **C4** include this correction.



**Fig B:** CSS data prior and after calibrating against a collocated Li-200 pyranometer.

Regarding the solar flux, Fig B includes the GHI reading from the collocated pyranometer showing the same 600 - 700  $\text{W m}^{-2}$  range as the CSS. Sky conditions between 1300 - 1400 PST as captured by our sky imager are shown in Fig C.

Scattered stratocumulus clouds from WNW ( $\sim 290^\circ$ ) partially occluded the sky starting at near noon, became overcast at 1400 PST and persisted for the remainder of the day. Despite the overcast conditions, the visibility of the solar corona behind the clouds indicates that the observed clouds were thin and transmitted higher solar irradiances than what one would typically expect under low overcast skies. Revolving back to comment C3, this day further demonstrates the utility of the CSS for relatively small solar variability.



**Fig C:** Sky images on 23 July 2013: (a) 1300 PST, (b) 1400 PST. The clouds observed at 1400 PST persisted for the remainder of the day.

**C6. Page 9059: Fig. 6:** Data presented in these plots are inconsistent with the information about FOV of the CSS. For example: at 16 PST the solar zenith angle is about 60 deg thus the CSS cannot see the sun. The information about sensor FOV should be reviewed.

**Response:** See response to comment for **C2**.